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EXAMINER	
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ART UNIT	**PAPER NUMBER**
1773	9

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Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

CLO 9

Office Action Summary	Application No.	Applicant(s)
	09/931,113	HIRAMOTO ET AL.
	Examiner	Art Unit
	Nikolas J. Uhlir	1773

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 13 August 2003.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-71 is/are pending in the application.

4a) Of the above claim(s) 3-4, 20,39-44, and 53-58 is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1,2,5-19,21,22,24-38,45-52 and 59-71 is/are rejected.

7)☒ Claim(s) 5,23,34 and 72 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4,6 .

4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other:

DETAILED ACTION

Election/Restrictions

1. Applicant's election of claims 1-52 and 59-72 in Paper No. 8 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)). Further, the examiner hereby acknowledges applicant's election of the species embodied by claims 5-16 and 61-64 (the product of the saturation magnetization X thickness of odd m is different then that of even m) for prosecution. Claims 1-2, 17-19, 21-38, 45-52, 59-60, and 65-72 are considered by the examiner to be generic to the elected species. Claims 3-4, 20, 39-44 stand as withdrawn from consideration as they are directed to non-elected species. Claims 53-58 stand as withdrawn from consideration as they are drawn to a non-elected invention. Accordingly, claims 1-2, 5-19, 21-38, 45-52, and 59-72 are pending

Priority

2. Receipt is acknowledged of papers submitted under 35 U.S.C. 119(a)-(d), which papers have been placed of record in the file.

Specification

3. The lengthy specification has not been checked to the extent necessary to determine the presence of all possible minor errors. Applicant's cooperation is requested in correcting any errors of which applicant may become aware in the specification.

Claim Objections

4. Claim 5 is objected to because of the following informalities: "any of" in line 1 of claim 5 should be deleted. Appropriate correction is required.

5. Claim 34 objected to because of the following informalities: Df/Da is a unitless ratio. "0.1nm" should be 0.1. Appropriate correction is required.

Claim Rejections - 35 USC § 112

6. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

7. Claims 8, 34, 36, 38, and 69-70 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

8. Claim 8 requires the demagnetization factor, determined from the effective film thickness and the free magnetic layer surface shape to be less than 0.02. It is unclear to the examiner how exactly the demagnetization fact is determined from the surface shape and effective film thickness of the free magnetic layer, as no detail is given in the specification as how this value is determined from these elements.

9. Claim 34 requires the thick ness da to be of "the ferromagnetic layer." There are many ferromagnetic layers in the structure required by claim 34, as the pinned layer is formed from "a plurality" of ferromagnetic layers. It appears however from the specification that da should represent the thickness of the antiferromagnetic layer.

10. Claim 36 requires the multilayer film to have a multilayer structure having a highly conductive metal layer including at least one selected from the group consisting of Ag, Au, and Cu as a main component, and a grain growth suppression layer, or a

compound selected from conductive oxides, nitrides, or carbides. It is unclear to the examiner whether this claim is a further limitation to the multilayer metal electrode required by claim 35 or the multilayer free layer required by claim 1. Further, it is unclear whether the claim requires the multilayer film to contain more then one of the recited layers. Does the claim require the multilayer to have a conductive layer **and** a grain suppression layer, or **at least one of** a conductive layer and a grain suppression layer?

11. Claim 38 has the same issues a claim 36.

12. Claims 69-70 refers to a total thickness of the magnetic layers. Is this the total thickness of the magnetic layers in the multilayer free or pinned layer only, or all of the magnetic layer in the structure?

Claim Rejections - 35 USC § 103

13. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

14. Claims 1-2, 5, 7-8, 10, 12-14, 17, 19, 31, 45-46, 51-52, 61-62, 64, 69 and 70 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill (US6275363) in view of Moon (Applied Physics Letters, Volume 74, #24, June, 14, 1999, pp. 3690-3692).

15. Claim 1 requires a magneto-resistive element comprising an intermediate layer, a pair of magnetic layer sandwiching the intermediate layer; wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer; wherein the free layer

is a multilayer film including at least one non-magnetic layer and magnetic layer sandwiching the non-magnetic layer; and wherein the element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film is $\leq 1000\mu m^2$.

16. While the examiner recognizes that it is his duty to interpret the claims in light of the specification, limitations from the specification are not read into the claims. Further, it is the examiners duty to give the claims their broadest reasonable interpretation. Thus, for the purpose of this examination, the examiner interprets claim 1 to be open to the inclusion of additional layers other then those specifically required. Further, the examiner interprets claim 1 to be open to the intermediate layer being conductive (spin valve) or non-conductive (tunnel junction).

17. Bearing the above interpretation in mind, Gill '363 teaches a dual magnetoresistive tunnel junction comprising an antiferromagnetic (AFM) layer 238, a double antiparallel (AP) pinned layer structure 204 on the AFM layer 239, tunnel junction barrier layers 218 and 302 on the double AP pinned layer 204, a double AP coupled free layer structure 202 on the tunnel junction barrier 302, a tunnel junction barrier layers 304 and 220 on the Ap coupled free layer 202, and a triple AO pinned structure 206 on the tunnel barrier layer 220 (figure 12). The tunnel junction barrier layers 304 and 220 are considered equivalent to applicant's claimed intermediate layer. Either of the double or triple AP pinned layer structures is equivalent to applicants pinned layer. The dual AP free layer structure is equivalent to applicants claimed free layer including at least a multilayer film.

18. Gill '363 fails to teach that the area of the intermediate layer is $\leq 1000\mu m^2$, as required by claim 1.

19. However, with respect to this deficiency, Moon et al. (Moon) teaches that the magnetic switching characteristics of a magnetoresistive tunnel junction can be controlled by controlling the area and shape of the junction (pp 3692, right column). Particularly, the magneto static coupling field between the free and pinned layers varies inversely with the length of the junction parallel to the applied field direction (pp 2692, right column). As shown by figure 3a, as the length of the junction increases, the offset field H_0 decreases, and vice versa. Thus, the examiner takes the position that the size and shape of a magnetoresistive tunnel junction is a results effective variable.

20. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of the tunnel junction (and thus of all of the layers making up the tunnel junction) in Gill '363 so as to achieve a desired level of coupling between the free and pinned layers.

21. The limitations of claim 2 require the area of the free layer to be larger than that of the element area. As shown by figure 12 of Gill '363, the tunnel junction 300 is formed such that the structure tapers from a relatively thin (width wise) top to a relatively wide bottom. As the tunnel barrier layers 220 and 304 to be equivalent to applicant's claimed intermediate layer, and the free layer 202 is equivalent to applicant's claimed free layer, it is evident from inspection that the area of the free layer is slightly larger than that of the barrier layer. Further, the uppermost magnetic layer in the free layer is 60A thick, whereas the total thickness of the barrier layers 220 and 304 is 15 angstroms. Thus, the

free layer area in a thickness direction necessarily exceeds the area of the barrier layers 220 and 304 in a thickness direction.

22. Claim 5 requires that when the magnetic layers are arranged at positions m (with M being an integer of 1 or greater), M is average saturation magnetization, d is average layer thickness, the sum of MmDm for odd m is different from the sum of the products of MmDm for even M. The specific example of Gill '363 cited above for claim 1 utilizes a double free layer having a 1st NiFe layer 210 having a thickness of 30 angstroms, and a 2nd NiFe layer 212 having a thickness of 60 angstroms (see figure 12). Thus, the limitations of claim 5 are met, as the 1st and 2nd NiFe layers are made of the same material but have a different thickness, and thus MmDm odd cannot equal MmDm even.

23. Claim 7 requires the non-magnetic layers to have a thickness >0.3nm but <2.6nm. The specific example of Gill '363 cited above for claim 1 utilizes a 8 angstrom Ru layer between the ferromagnetic layers in the free layer. Thus, the limitations of claim 7 are met.

24. Regarding the limitations of claim 8, in the example cited from Gill '363, (M1D1+M2D2)/(M1D1-M2D2)* is 3, as NiFe has a saturation magnetization of ~1, so (30+60)/(30-60)* (* denotes absolute value of the lower parenthetical expression) equals 3. Thus, as the equation limitations of claim 8 are met, the examiner takes the position that the demagnetization fact required by claim 8 is also met.

25. Claim 10 requires the free layer to comprise first and second magnetic layers separated by a non-magnetic spacer, wherein MmDm2 is > MmDm 1, and requires the magnetic resistance to display at least one maximum or minimum with respect to

change in external magnetization. This limitation is met by the particular example of Gill '363 cited above for claim 1. In that example, Gill '363 utilizes a free magnetic layer which comprises a lower 30 A NiFe layer (equivalent to applicants claimed 1st magnetic layer), an upper 60 angstrom NiFe layer (equivalent to applicants claimed 2nd magnetic layer), and a 8 angstrom thick Ru layer separating the magnetic layers. Thus, MmDm2 is greater than MmDm1 in this example. With respect to applicants claimed requirement that the magnetic resistance display at least one maximum or minimum with respect to change in external magnetization, it is the examiners position that this limitation is met by Gill '363 as modified by Moon, as this combination meets all of the structural requirements of the claim.

26. Claim 12 requires the free magnetic layer to be sandwiched between two intermediate layers. This limitation is met ass et forth above for claim 1, as the example cited from Gill '363 utilizes a tunnel barrier layer (equivalent to applicant's intermediate layer) above and below the free layer.

27. Claim 13 requires the free magnetic layer to comprise 2n magnetic layers and 2n-1 non-magnetic layers layered in alternation, wherein n is an integer of 1 or more. This limitation is met as set forth above for claim 1.

28. Claim 14 requires element of claim 13 to comprise a first pinned layer, first intermediate layer, free layer, second intermediate layer, and second pinned layer formed in that order, wherein the free layer is a multilayer film comprising a first magnetic layer, non-magnetic layer, and second non-magnetic layer formed in that order from the side of the first pinned layer, wherein M2D2 does not equal M1D1. These

limitations are met as set forth above for claim 1. the AP pinned layer structure 204 of Gill '363 is equivalent to applicants claimed first pinned layer, the tunnel barrier layers 222 and 226 are equivalent to applicant's claimed 1st intermediate, the free layer 202 has the required structure and MmDm characteristics, the tunnel barrier layer 304 and 220 are equivalent to applicant's claims 2nd intermediate, and the AP pinned layer 206 is equivalent to applicants claimed 2nd pinned layer.

29. Claim 17 requires one of the magnetic layers in the free magnetic layer to have a coercivity and saturation magnetization that is different from at least one of the other magnetic layers. The examiner interprets "one of the other magnetic layers" to include the pinned layer. Thus limitation is met as set forth above for claim 1, as Gill '363 utilizes CoFe magnetic layers in the pinned layers and NiFe magnetic layers in the free layers. CoFe is known to have a higher saturation magnetization than NiFe, and coercivity is known to be impacted by a number of factors, including material composition. Thus, it is the examiners position that at least one of the magnetic layers in the free layer of Gill '363 has a different coercivity and saturation magnetization than one of the other magnetic layers in the structure, more specifically the CoFe layers utilized in the pinned layers.

30. Claim 19 requires a magnetoresistive element which comprises an intermediate layer; a pair of magnetic layers sandwiching the intermediate layer; wherein one fo the magnetic layers is a pinned magnetic layer which is a multilayer film comprising at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; wherein the thickness of the non-magnetic layer is between 0.3-2.6nm; wherein the

pinned layer is in contact with a primer layer or an AFM layer, and the element area is $\leq 1000 \mu m^2$.

31. The limitations of claim 19 are met as set forth above for claim 1. The specific example of Gill '363 utilizes both Dual and Triple AP pinned films, wherein the pinned films are in contact with an AFM layer. The spacers between adjacent magnetic layers in the pinned films are 8 angstroms thick. Thus, all of the limitations of claim 19 are met.

32. Claim 31 requires the magnetic layer in contact with the AFM layer to be made of Co. This limitation is met by the specific example cited above for claim 1, as Gill '363 utilizes Co or CoFe to form the magnetic layer touching the AFM layer (see figure 12).

33. The limitations of claims 45-46 require the free magnetic layer of the magnetoresistive elements of claims 1 and 19 to serve as a memory layer. These limitations are intended use limitations and do not appear to be further limiting in so far as the structure of the product is concerned. In apparatus, article, and composition claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. In a claim drawn to a process of making, the intended use must result in a manipulative difference as compared to the prior art. It is the examiners position that the free magnetic layer utilized by Gill '363 as modified by Moon is capable of functioning as a memory layer. Thus, these limitations are met.

34. Claim 51-52 require the element shape of the free magnetic layer to be controlled so that the ratio of the longest width of the free layer to the shortest width of the free

layer is between 1.5-10. Though not expressly taught by the combination of Gill '363 with Moon, the examiner maintains that it would be obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of a spin valve (and thus the length and width of all of the layers making up the spin valve) so as to achieve a desired amount of coupling between the free and pinned layers, per the teaching in Moon.

35. Claims 61 and 62 require the magnetoresistive element of claim 12 to comprise a first pinned layer, a first intermediate layer, a first free layer, a non-magnetic conductive layer, a second free layer, a second intermediate layer, and a second pinned layer formed in that order, wherein at least one of the free layers includes 1 or more magnetic layers and 1 or more non-magnetic layer layered in alternation, such that the adjacent magnetic layers which are spaced apart by a non-magnetic layer are orient antiparallel to one another.

36. The tunnel junction cited above for claim 1 utilized by Gill '363 meets these limitations. The tunnel junction of figure 12 includes a lower AP pinned layer 204 (equivalent to applicants claimed 1st pinned layer), A double AP coupled free layer structure 202 (layer 214 is equivalent to applicants 1st free layer and layers 216, 304 are equivalent to applicants claimed free layer having 1 or more magnetic layers and non-magnetic layers layered in alternation), and double AP pinned layer 206 (equivalent to applicant's claimed 2nd pinned layer. The free layers 214 and 216 are oriented AP to one another. Thus, the limitations of claims 61-62 are met.

37. Claim 64 requires the magnetoresistive element of claim 12 to comprise 4 pinned magnetic layers, two free magnetic layers, and four intermediate layers, wherein at least one of the free layers is a multilayer film comprising one or more magnetic layers layered in alternation with one or more non-magnetic layers. These limitations are met as set forth above for claim 1. Figure 12 discloses four pinned magnetic layers (240, 242, 250, 248), multiple free layers (214, 216) wherein one of the free layers is at least one or more magnetic layers layered in alternation with one or more non-magnetic layers (208, 221) and 4 intermediate layers (218, 302, 304, 220). Thus, the limitations of claim 64 are met.

38. Claims 69-70 require the total thickness of the magnetic layers of claim 1 or claim 19 to be ≥4nm. The examiner interprets these claims to require the sum total thickness of all of the magnetic layers (free, pinned, AFM etc.) in the magnetoresistive structure must be ≥4nm. This limitation is met as set forth above for claim 1 and shown in figure 12 of Gill '363.

39. Claims 1, 2, 5, 7, 10-12, 15-17, 19, 31, 34, 45-46, 51-52, 61-62, and 69-70 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill (US6271997) in view of Moon.

40. With respect to the limitations of claim 1, the spin valve structure of Gill '997 shown by figure 14 meets most of the limitations of the limitations of claim 1. However, Gill '997 fails to teach the required element area.

41. Regarding this deficiency, Moon et al. (Moon) teaches that the magnetic switching characteristics of a magnetoresistive tunnel junction can be controlled by controlling the area and shape of the junction (pp 3692, right column). Particularly, the magneto static coupling field between the free and pinned layers varies inversely with the length of the junction parallel to the applied field direction (pp 2692, right column). As shown by figure 3a, as the length of the junction increases, the offset field H_0 decreases, and vice versa. Thus, the examiner takes the position that the size and shape of a magnetoresistive element is a results effective variable.

42. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of the spin valve (and thus of all of the layers making up the spin valve) in Gil '997 so as to achieve a desired level of coupling between the free and pinned layers.

43. Once again, though the examiner recognizes that spin valves and tunnel junctions are patentably distinct inventions, one of ordinary skill in the art would know that much of the technology utilized in these structures is the same. Thus, these references are not non-analogous art, and one of ordinary skill in the art would have been motivated with a reasonable expectation of success in modifying the Gill '997 with the teachings of Moon.

44. Regarding the limitations of claim 2. As shown by figure 14 of Gill '997, the spin valve 400 is formed such that the structure tapers from a relatively thin (width wise) top to a relatively wide bottom. The examiner considers Cu spacer 210 as equivalent to applicants claimed intermediate layer. Thus, it is clear from inspection that Cu spacer

210 has a slightly smaller area width wise than that of the free layer 202. Further, the intermediate layer is 20 angstroms thick, whereas the upper most free layer is 30 angstroms thick. Thus, the area in a vertical direction of the free layer necessarily exceeds that of the intermediate layer.

45. Regarding the limitations of claim 5, the triple free layer structure of Gill '997 utilizes a lower 10 angstrom thick CoFe layer, a middle 20 angstrom thick NiFe layer, and an upper 30 angstrom thick CoFe layer (see figure 14). Thus, the MmDm limitations of claim 5 are met.

46. Regarding the limitations of claim 7, Gill '997 teaches the use of 8 angstrom non-magnetic layers in the free layer structure. Thus, the limitations of claim 7 are met.

47. Regarding the limitations of claim 10, these limitations are met by the spin valve set forth in figure 14 of Gill '997. the examiner considers the middle NiFe layer 220 to be equivalent to applicants claimed 1st magnetic layer in the free layer. The Ru layer 226 is equivalent to applicant's claimed non-magnetic layer, and the CoFe layer 222 is equivalent to applicant's claimed 2nd magnetic layer. Given that CoFe has a higher saturation magnetization then NiFe, and the CoFe layer 222 of Gill'997 is thicker than the NiFe layer 220, the MmDM limitations of claim 9 are met. Regarding the requirement that the magnetic resistance displays at least one maximum or minimum with respect to change in external magnetization, the examiner takes the position that this limitation is met by Gill '997 as modified by Moon, as the free layer structure of Gill '997 meets all of the structural requirements of claim 9 and is AP oriented.

48. The limitations of claim 11 require the magneto-resistive element of claim 5 to comprise a triple free layer, wherein M3D3 >M2D2 and M3D3>M1D1 and a coupling magnetic field of the first magnetic layer and the second magnetic layer is smaller than the memory reversal magnetic field, and the magnetization state of the third magnetic layer is detected by applying a magnetic field that is smaller than the memory reversal magnetic field but is larger than the coupling magnetic field in a memory direction of the magnetization of the third magnetic layer.

49. The spin valve structure shown by figure 14 of Gill '997 meets all of the structural and MmDm requirements of claim 11. Regarding the coupling and reversal field requirements, the examiner takes the position that these limitations are met, as the spin valve of Gill '997 utilize a trilayer layer free layer which meets all of the applicants MmDm requirements. Further, Gill '997 utilizes CoFe as a third magnetic layer and NiFe as a second magnetic layer. CoFe is known to generally have higher coercivity than NiFe, and is known to have a coercivity that increase with thickness. Thus, as the third free layer of Gill '997 is made of CoFe and is thicker than the 1st CoFe layer, it will be the highest coercivity magnetic layer. The applicant states on page 10, lines 9-37 that when the MmDm limitations are met and the third layer has a highest coercivity in the triple free layer, the coupling and reversal field limitations are met. Thus, as the spin valve taught by Gill '997 meets the statement in the specification, these limitations are met.

50. Regarding the method of detecting the magnetization state of the third magnetic layer. This is a process limitation that does not appear to be further limiting in so far as

the structure of the product is concerned. Determination of patentability of a product is based on the product itself. The patentability of a product does not depend on its method of evaluation. Thus, though the examiner has considered the process limitations, as they do not appear to further limit the product, the examiner takes the position that the limitations of claim 11 are met.

51. The limitations of claim 12 are met as set forth above for claim 5.

52. The limitations of claim 15 are met as set forth above for claim 12.

53. The limitations of claim 16 require a magnetoresistive element that has a 1st pinned layer, a first intermediate layer, a free magnetic layer, a second intermediate, and a second pinned magnetic layer formed in that order,wherein the free magnetic layer is a multilayer film comprising having the structure: 1st magnetic/1st non-magnetic/second magnetic/ second non-magnetic/third magnetic formed in that order from the side of the first pinned layer, wherein M3D3+M1D1 does not equal M2D2. All of these structural limitations are met by the spin valve shown by Gill '997 in figure 14. Thus, when this spin valve is modified by Moon, a ll of the limitations of claim 16 are met.

54. All of the limitations of claim 19 are met as set forth above for claim 1.

55. Claim 31 is met as set forth above for claim 19. The limitation "made of Co" is open language which is interpreted by the examiner to simply require that the magnetic layer contacting the AFM layer to contain Co. Thus, as the layer contacting the AFM layer in figure 14 of Gill '997 contains Co, this limitation is met.

56. Claim 34 requires 2nm ≤df ≤ 50nm, 5nm≤da≤100nm, and 0.1nm≤df/da≤5, wherein df is the thickness of the pinned layer, and da is the thickness of the ferromagnetic layer. For the purpose of this examination, the examiner interprets Df to refer to the total thickness of the magnetic layers in the pinned layer. Further, the examiner interprets Da to refer to the thickness of the antiferromagnetic layer, as is commensurate in scope with the specification. Last, the examiner interprets the ratio df/da as a unit less value (0.1nm should be 0.1). Bearing these interpretations in mind, the spin valve embodied by figure 14 of Gill '997 has a pinned layer that is 45 angstroms thick, and the AFM layer contacting the pinned layer is 60-80 angstroms thick. Thus, the ratio df/da is 0.56-0.75. Thus, the limitations of claim 34 are met.

57. The limitations of claims 45-46 require the free magnetic layer of the magnetoresistive elements of claims 1 and 19 to serve as a memory layer. These limitations are intended use limitations and do not appear to be further limiting in so far as the structure of the product is concerned. In apparatus, article, and composition claims, intended use must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. In a claim drawn to a process of making, the intended use must result in a manipulative difference as compared to the prior art. It is the examiners position that the free magnetic layer utilized by Gill '997 as modified by Moon is capable of functioning as a memory layer. Thus, these limitations are met.

58. Claims 51-52 require the elements of claims 1 and 19 to have a specific ratio of length to width. Though not expressly taught by either Gill '997 or Moon, the examiner maintains that it would have been obvious to one of ordinary skill in the art to control the dimensions of the spin valve taught by Gill '997 per the teachings in Moon to attain a desired level of coupling between the layers in the structure.

59. The limitations of claims 61-62 are met by Gill '997 as modified by Moon. The examiner considers the triple free layer 202 of Gill '997 shown in figre 14 to meet all of the applicants claimed free layer requirements. The pinned layer 204 and pinned layer 402 meet the applicants requirements of a 1st and second pinned layer. Further, the magnetic free layers are all oriented antiparallel.

60. Claims 69-70 is met by Gill '997 as modified by Moon. The total thickness of the magnetic layers in the structure shown by Figure 14 of Gill '997 clearly exceed 4nm. The examiner notes that the magnetic layer thickness requirement has been interpreted to mean the total thickness of all of the magnetic layers in the structure (i.e. free, pinned and AFM).

61. Claims 1, 19, 22, and 71 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sakakima (Journal of Magntism and Magnetic Materials 210 (2000) L20-24) in view of Moon.

62. Regarding claim 1, Sakakima discloses a spin valve which has the structure: AF/pinned layer/Cu spacer/free layer, wherein the pinned and free layers each have a thin oxide layer inserted, so as to form free and pinned layer structures having a first

lower magnetic layer and a second upper magnetic layer separated from each other by the oxide layer (L21 figure 1b). This structure meets all of the limitations of claim 1 except that Sakakima does not teach the required element area of claim 1.

63. However, Moon et al. (Moon) teaches that the magnetic switching characteristics of a magnetoresistive tunnel junction can be controlled by controlling the area and shape of the junction (pp 3692, right column). Particularly, the magneto static coupling field between the free and pinned layers varies inversely with the length of the junction parallel to the applied field direction (pp 2692, right column). As shown by figure 3a, as the length of the junction increases, the offset field H_0 decreases, and vice versa. Thus, the examiner takes the position that the size and shape of a magnetoresistive tunnel junction is a results effective variable.

64. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of the spin valve (and thus of all of the layers making up the spin valve) in Sakakima so as to achieve a desired level of coupling between the free and pinned layers.

65. Regarding the limitations of claim 19, Sakakima teaches that the oxide layers are between 1-1.4nm thick. Thus, coupled with the discussion above for claim 1, all of the limitations of claim 19 are met.

66. Regarding the limitations of claims 22 and 71, Sakakima discloses using oxide interlayers in the free and pinned layers. Thus, these limitations are met.

67. Claims 19 and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill (6407890) in view of Moon.

68. Regarding the limitations of claim 19, figure 12 of Gill '890 discloses a spin valve which meets all of the limitations of claim 19, except that it doesn't teach the required element area.

69. However, Moon et al. (Moon) teaches that the magnetic switching characteristics of a magnetoresistive tunnel junction can be controlled by controlling the area and shape of the junction (pp 3692, right column). Particularly, the magneto static coupling field between the free and pinned layers varies inversely with the length of the junction parallel to the applied field direction (pp 2692, right column). As shown by figure 3a, as the length of the junction increases, the offset field H_0 decreases, and vice versa. Thus, the examiner takes the position that the size and shape of a magnetoresistive tunnel junction is a results effective variable.

70. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of the tunnel junction (and thus of all of the layers making up the tunnel junction) in Gill '890 so as to achieve a desired level of coupling between the free and pinned layers.

71. Regarding the limitations of claim 22, Gill '890 teaches the use of an oxide layer for the purpose of separating adjacent pinned magnetic layers. This oxide layer is an Iron oxide, and can be magnetic or nonmagnetic (column 3, lines 33-45).

72. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a non-magnetic ferromagnetic oxide layer between

adjacent pinned magnetic layers, as Gill '890 recognizes the equivalency of non-magnetic iron oxide to magnetic iron oxide for this purpose.

73. Claims 6 and 63 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill in view of Moon as applied to claims 5, and 61 above, and further in view of Gurney (US5408377).

74. Gill in view of Moon as applied to claim 5 above fails to teach the limitations of claim 6, which requires the non-magnetic layer(s) separating two free magnetic layers to have a thickness between 2.6-10nm.

75. However, with respect to this deficiency, Gurney et al. teaches that the thickness of an Ru non-magnetic spacer layer between two NiFe magnetic layers in a magnetoresistive element impacts the saturation field exhibited by the magnetic layers, with thicker non-magnetic layers exhibiting resulting in a reduction in saturation field and vice versa (figure 7 and column 3, lines 1-3). Thus, the examiner takes the position that the thickness of the non-magnetic spacer layer is a results effective variable.

76. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the thickness of the non-magnetic spacer layer 208 utilized by Gill as modified by Moon, so as to achieve a desired level of saturation field exhibited by the free layer.

77. The limitations of claim 63 are met as set forth above for claims 6 and 61.

78. Regarding the combination of Gurney with Gill and Moon. The examiner acknowledges that Gurney is directed towards a spin valve structure, whereas Gill and

Moon are directed towards tunnel junctions. Though these inventions are patentably distinct, they utilize many similar or identical components, including free layer structures, pinned layer structures, capping layers etc. One of ordinary skill in the art would readily recognize that much of the technology in spin valves and tunnel junctions is interchangeable. Thus, these references are not non-analogous to one another. Further, the examiner acknowledges that Gill only specifically teaches that a suitable thickness for the non-magnetic Ru spacer layer is 8 angstroms. However, Gill does not teach away from any other thickness, and thus the combination of Gill with Gurney does not destroy the reference.

79. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claim 5 above, and further in view of Tsuge (6329078).

80. Gill '363 as modified by moon as applied to claim 5 does not teach all of the limitations of claim 9, specifically the requirement that the first magnetic layer in the free layer structure be made of a high spin polarization material at least at the interface with the intermediate layer.

81. However, Tsuge teaches a tunnel juction which has the structure AFM/pinned/intermediate/Free (column 5, lines 45-57). Tsuge teaches that the magnetoresistance ratio of a ferromagnetic tunnel junction is improved if the free layer includes at least a high polarization layer and a soft magnetic layer, wherein the high polarization layer is located closer to the intermediate layer then the soft magnetic layer

(column 5, lines 50-65). Suitable materials for the high polarization include a NiFe alloy containing up to 35 atomic % Ni (column 6, lines 20-21).

82. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a NiFe alloy containing up to 35 atomic % Ni as taught by Tsuge as the lower NiFe layer in the free layer taught by Gill '262 as modified by Moon.

83. One would have been motivated to make this modification in light of the teaching in Tsuge that the magnetoresistance ratio of a tunnel junction is improved by using a high polarization layer in the free magnetic layer, such that the high polarization layer adjacent the non-magnetic intermediate layer.

84. Claims 18, 21, and 59-60 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '997 as modified by Moon as applied to claims 1, 5, and 19 above, and further in view of Parkin (Journal of Applied Physics, Vol. 85, #8, pp. 5828-5833).

85. Gill '363 as modified by Moon above fails to teach all of the limitations of claim 18 which requires a first element according to claim 5, which comprises a free layer structure wherein a first magnetic layer, non-magnetic layer, and 2nd magnetic layer are layered in this order from the intermediate layer, wherein M2D2>M1D1 and additionally a 2nd element according to claim 5 is present, wherein the second element comprises a 3rd magnetic layer and a 4th magnetic layer formed in this order from a 2nd intermediate layer, such that M3D3 >M4D4, wherein the 1st and 2nd elements respond

to the same magnetic field and their outputs are either subtracted or added to one another.

86. It is noted that claim 18 utilizes open language. Thus, this claim has been interpreted to having other layers (magnetic or otherwise) inserted at any given point in the structure, so long as the general structure is met.

87. However, it is noted that Gill teaches an example of a spin valve which has a free layer above an intermediate layer, wherein the free layer comprises a lower 10 angstrom thick CoFe layer, an 8 angstrom thick Ru spacer, a 30 angstrom thick NiFe magnetic layer, an 8 angstrom thick Ru spacer, and an upper 10 angstrom CoFe layer (see figure 12).

88. Further, Parkin teaches that magnetic random access memory (MRAM) can be manufactured from magnetic spin valves and magnetic tunnel junctions (page 5828 left column). To manufacture this MRAM, multiple giant magnetoresistance elements are deposited in close proximity to one another and connected in series (page 5829 left column).

89. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture many of the spin valves shown by figure 12 of Gill '997 and connect them in series per the teachings in Parkin, so as to attain a magnetic random access memory.

90. One would have been motivated to make this modification in light of the teaching in Parkin that by forming multiple GMR spin valves in close proximity to one another and linking them in series, an MRAM can be manufactured.

91. Thus, Gill' 997 as modified by Moon and Parkin results in a MRAM having multiple spin valve linked in series. Regarding the MmDm requirements of claim 18, the examiner interprets that the middle 30 angstrom thick NiFe layer is equivalent to applicants claimed 2nd magnetic layer in for the first element and 3rd magnetic layer in the 2nd element. The examiner interprets the lower 10 angstrom thick CoFe layer to be equivalent to applicants claimed 1st magnetic layer in the 1st element. The upper 10 angstrom thick CoFe layer is equivalent to applicants claimed 4th magnetic layer. Thus, as NiFe is known to have a saturation magnetization of ~1 tesla and CoFe has a saturation magnetization of ~2 tesla, M2D2 is greater than M1D1 in the first element and M3D3 is greater than M4D4 in the second element. Thus, all of the limitations of claim 18 are met.

92. The examiner acknowledges that the spin valve taught by Gill '997 is directed towards being used as a sensor. However, one of ordinary skill in the art, seeing the teaching in Parkin that spin valve structures having essentially the same components as that of Gill (pinned, free and spacer layers) would recognize that the spin valve structure taught by Gill would be suitable for use in an MRAM.

93. Regarding claim 21, these limitations are met by the combination of Gill '997 with Moon and Parkin. Figure 12 of Gill '997 clearly shows that the spin valve structure has a lower double AP pinned structure (meeting applicants claimed 1st element having 2n magnetic layers and 2n-1 non-magnetic layers), and an upper triple AP pinned layer (meeting applicants claims pinned layer having 2n+1 magnetic layers and 2n non-magnetic layers). Thus, the limitations of claim 21 are met.

94. Claims 59-60 require the magnetoresistive elements of claims 1 and 19 to store data in their free magnetic layers, wherein the data is communicated by electromagnetic waves. These limitations are intended use limitations that do not appear to further limit the structure of the final product. It is the examiners position that the free layers of Gill '997 as modified by Moon and Parkin are capable of performing the recited intended use. Thus, these limitations are met.

95. Claims 24-26, 28-29, 35-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claims 1 and 19 above, and further in view of Fuke et al. (US6313973).

96. Gill '363 as modified by Moon as applied to claims 1 and 19 above does not teach all of the limitations of claims 24-25, specifically the requirements of a primer layer containing at least one element from groups IVa-VIa and VIII but excluding Fe, Co, and Ni and Cu (claim 24), more specifically wherein the primer layer is in contact with a magnetic layer and the primer layer and the magnetic layer have at least one crystal structure selected from FCC and HCP, or the primer layer and the magnetic layer both include a bcc structure (claim 25).

97. It is noted that neither claims 24 or 25 require the primer layer to be in contact with one of the pinned magnetic layers. Rather, they mere require the primer to be touching "a" magnetic layer. Thus, if the primer layer touches an AFM layer, these limitations are met.

98. However, Fuke et al. (Fuke) teaches utilizing one or more underlayers (equivalent to applicants claimed primer layer) underneath the AFM layers in magnetoresistive elements to improve the crystal growth of the AFM layer (column 10, lines 4-19). One of the underlayers should be in contact with the AFM layer (column 20-25). Suitable AFM layers include IrMn (fcc) and RhRuMn (Fcc), and suitable underlayers include Ti, Zr, Hf, Re, Ru, Os, Rh, IR, Pd, Pt, Cu, Ag, Au, Zn, Cd, Al, Ti, and Pb, all of which have either an hcp or fcc structure.

99. Therefore it would have been obvious to one of ordinary skill in the art to utilize a Ti, Zr, Hf, Re, Ru, Os, Rh, IR, Pd, Pt, Ag, Au, Zn, Cd, Al, Ti, or Pb underlayer and as taught by Fuke in the spin valve taught by Gill '363 as modified by Moon.

100. One would have been motivated to make this modification in light of the teaching in Fuke that the crystallinity of an AFM layer in a magnetoresistive element is improved by utilizing an underlayer that is made from one of the cited elements.

101. It is noted that suitable materials for the AFM layer taught by Gill '363 is formed from IrMn, FeMn, or NiO (see column 7, lines 60-65). As shown by Fuke, IrMn has an FCC structure. Thus, all of the limitations of claims 24-25 are met when IrMn is utilized as the AFM layer.

102. Regarding the limitations of claims 26, Fuke teaches that suitable AFM layers for magnetoresistive elements are manufactured from R_xMn_{100-x} wherein R can be an element such as Ir when x is between 5-40 and R can be Cr when x is 40-60 (column 11, lines 15-45).

103. Therefore it would have been obvious to one of ordinary skill in the art to substitute a CrMn containing 40AFM layer as taught by Fuke for the IrMn AFM layer taught by Gill '363 as modified by Moon, as Fuke teaches the equivalence of CrMn to IrMn as a suitable material for forming an AFM layer in a magnetoresistive element.

104. Regarding the limitations of claim 28, Fuke teaches that a suitable Afm layer can comprise an R_xMn_{100-x} layer, wherein x is 5-40 atomic % and R can be selected from a group including Ir, Pt and Pd.

105. Therefore it would have been obvious to one of ordinary skill in the art to substitute a $Pt_{40}Mn_{60}$ or $Pd_{40}Mn_{60}$ AFM layer as taught by Fuke for the Afm layer taught by Gill '363 as modified by Moon, as Fuke teaches the equivalence of $Pt_{40}Mn_{60}$ or $Pd_{40}Mn_{60}$ to IrMn as suitable for use an Afm layer in a magnetoresistive element.

106. Regarding claim 29, these limitations are met as set forth above for claim 25.

107. Regarding claim 35, wherein the applicant requires the magnetoresistive element to be formed on a multilayer electrode. Fuke teaches that the underlayer can comprise a multilayer film of Ti, Zr, Hf, Re, Ru, Os, Rh, IR, Pd, Pt, Ag, Au, Zn, Cd, Al, Ti, or Pb (column 10, lines 25-35).

108. Therefore it would have been obvious to one of ordinary skill in the art to form a multilayer film of Ti, Zr, Hf, Re, Ru, Os, Rh, IR, Pd, Pt, Ag, Au, Zn, Cd, Al, Ti, or Pb as taught by Fuke beneath the AFM layer taught by Gill '363 as modified by Moon in order to improve the crystallinity of the AFM layer.

109. It is the examiners position that the multiayer Ti, Zr, Hf, Re, Ru, Os, Rh, IR, Pd, Pt, Ag, Au, Zn, Cd, Al, Ti, or Pb film formed below the Afm layer is equivalent to applicants claimed multilayer electrode.

110. Regarding claim 36, wherein the applicant requires the multilayer film to have a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al, Cu, as a main component and a grain growth suppression layer of a metal having at least one element selected from groups IVa-VIA and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, nitrides, and carbides.

111. For the purpose of this examination the examiner interprets claim 36 to mean that the multilayer electrode must have at least one of the components recited.

112. Bearing this interpretation in mind, as noted above for claim 35, Fuke teaches utilizing a multilayer Ti, Zr, Hf, Re, Ru, Cu, Os, Rh, IR, Pd, Pt, Ag, Au, Zn, Cd, Al, Ti, or Pb layer beneath an AFM layer in magnetoresistive element.

113. Therefore it would have been obvious to one of ordinary skill in the art to utilize a multilayer film containing Au, Ag, Al, or Cu in the multilayer underlayer utilized by Gill '363 as modified by Moon and Fuke, as Fuke teaches the equivalency of Ag, Al, Cu, or Au to the other materials listed as suitable for forming the multilayer underlayer.

114. Claims 38-39 are met as set forth above for claims 35-36.

115. Claim 27 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claim 19 above, and further in view of Nishioka et al.

(US5648885).Gill '363 as modified by Moon as applied to claim 19 fails to teach a $Cr_{100-x}Me_x$ AFM layer, wherein x is 0.1-20 and Me is Re, RU, or Rh, as required by Claim 26.

116. However, Gill '363 does teach the FeMn is a suitable material for the AFM layer (column 7, lines 44-67). Further, Nishioka et al. (Nishioka) teaches a magnetoresistive element, and teaches the use of FeMn and CrRu antiferromagnetic layers, wherein the CrRu AFM layer contains 1 atomic % Ru (sections 103-104).

117. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute the $CrRu_1$ AFM layer as taught by Nishioka for the FeMn AFM layer utilized by Gill '363, as Nishioka recognizes the equivalency of $CrRu_1$ to FeMn as suitable materials for use as an AFM layer in a magnetoresistive element.

118. Claims 29-30 rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claim 19 above, and further in view of Aoshima (US6046892).

119. Gill '363 as modified by Moon as applied to claim 19 above fails to teach that the Afm layer is formed on a primer layer, wherein the primer layer is NiFe or NiFeCr which has been processed at 300^0 C, and the AFM layer and the primer layer layer have at least one crystal structure selected from fcc, fct, hcp, and hct, or both the primer and AFM layer have a bcc structure, as required by claims 29-30.

120. However, it is noted that Gill '363 does teach that IrMn is a suitable AFM layer. IrMn is known to have a fcc structure. Further, Aoshima teaches that by utilizing a particular underlayer beneath the AFM layer in a magnetoresistive element, current loss

in the AFM layer can be prevented. Suitable underlayers for this purpose are manufacture from a NiFe alloy that additionally contains at least one additive selected from Cr, Nb, Rh, and Pd. (column 1, line 64-column 2, line 13). These underlayers are treated at 280^0 C (column 4, lines 38-50).

121. Therefore it would have been obvious to one of ordinary skill in the art at the time to utilize an underlayer of NiFeCr which has been heat treated at 280^0 C as taught by Aoshima beneath the AFM layer taught by Gill '363 as modified by Moon.

122. one would have been motivated to make this modification due to the teaching in Aoshima that current loss in the AFM layer can be prevented by utilizing this underlayer beneath the AFM layer.

123. Regarding the crystal structure of the NiFeCr underlayer, it is the examiners position that the NiFeCr underlayer taught by Aoshima will have one an fcc, fct, hcp, or hct crystal structure, as this underlayer matches the alloy listed as suitable for this purpose in the specification. Further, the limitations requiring the underlayer to be thermally processed at 300^0 C are product by process limitations which do not appear to impact the structure of the final product. Even though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process. In this case, it is the examiners position that a NiFeCr

alloy that has been annealed at 280^0 C is substantially the same as a NiFeCr alloy annealed at 300^0 C, as no evidence has been presented to show otherwise.

124. Claim 32 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claim 19 above, and further in view of Gill (US6108177).

125. Gill '363 as modified by Moon as set forth above fails too teach a magnetic layer in contact with the AFM layer or non-magnetic layer which is a ferromagnetic material including oxygen, nitrogen, or carbon, as required by claim 32.

126. However, Gill '177 teaches that suitable materials for pinned layers in magnetoresistive elements include FeN, Co, or CoFe (co0lumn 4, lines 40-45).

127. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize FeN as taught by Gill '177 to form the pinned layers taught by Gill '363 as modified by Moon, as Gill '177 recognizes the equivalency of FeN to Co, or CoFe as suitable materials for forming the pinned layers of a magnetoresistive element.

128. Claim 33 is rejected under 35 U.S.C. 103(a) as being unpatentable over Gill' 363 as modified by Moon as applied to claim 19 above, and further in view of Hayashi et al. (US6133732).

129. Gill' 363 as modified by Moon as set forth above does not teach all of the limitations of claims 33, more specifically a magnetoresistive element which utilizes a

magnetic film in contact with a primer or AFM layer, wherein the magnetic film is an amorphous ferromagnetic material.

130. However, Hayashi teaches a magnetoresistive element which comprises an Afm layer, a pinned magnetic layer, and a free magnetic layer. The pinned layer may comprise multiple layers, wherein the magnetic layers can be made from Co based, Ni based, Fe based materials or alloys thereof. Alternatively, the pinned layer in contact with the AFM layer can be made from amorphous magnetic materials 9column 5, line 55-column 6, line 20).

131. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute an amorphous magnetic layer as taught by Hayashi for the pinned magnetic layer touching the AFM layer utilized in Gill '363 as modified by Moon, as Hayashi teaches the equivalency of amorphous magnetic materials to Co and Fe alloys as suitable magnetic materials for forming the pinned layer in contact with the AFM layer in a magnetoresistive element.

132. Further, Hayashi teaches that the free magnetic layer can comprise iron nitride based materials, or Co alloys such as FeCo, NiFe, or others (column 6, lines 20-38).

133. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute and iron nitride as taught by Hayashi for the NiFe free magnetic layers utilized by Gill '363 as modified by Moon, as Hayashi teaches the equivalency of iron nitrides to NiFe as suitable materials for forming free layers in a magnetoresistive element.

134. When an iron nitride is substituted for the NiFe free layers of Gill '363 as modified by Moon, at least one of the magnetic layers touching the intermediate layer is

135. Claims 47-50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gill '363 as modified by Moon as applied to claim 1, and 19 above, and further in view of Fontana Jr. et al. (US5901018).

136. Gill '363 as modified by Moon above does not teach a magnetoresistive element which has a flux guide, wherein a portion of the free layer acts as the flux guide, as required by claims 47-50.

137. However, Fontana teaches that the amount of flux present in the active region of the free magnetic layer in a magnetoresistive element is increased by extending the free magnetic layer beyond the active region of the element. This extended portion of the free layers acts as a flux guide. A magnetoresistive element utilizing this flux guide has greater output then a magnetoresistive element without flux guide. (column 8, lines 44-65).

138. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to extend the free layer taught by Gill '363 as modified by Moon beyond the active region of the element, thereby creating a flux guide.

139. One would have been motivated to make this modification in lieu fo the teaching in Fontana that the output of a magnetoresistive element is increased by forming a flux guide from an extended portion of the free layer.

140. Claims 1, 19, and 65-68 are rejected under 35 U.S.C. 103(a) as being unpatentable over Saito et al. (US6639764) in view of Moon and Kamiguchi (US5949622).

141. Regarding the limitations of claims 1 and 19, the magnetoresistive element shown by figure 9 and discussed at column 62, lines 5-50 meet most of the structural limitations of claims 1 and 19, except for the element area.

142. With respect to the element area, Moon et al. (Moon) teaches that the magnetic switching characteristics of a magnetoresistive tunnel junction can be controlled by controlling the area and shape of the junction (pp 3692, right column). Particularly, the magneto static coupling field between the free and pinned layers varies inversely with the length of the junction parallel to the applied field direction (pp 2692, right column). As shown by figure 3a, as the length of the junction increases, the offset field H_0 decreases, and vice versa. Thus, the examiner takes the position that the size and shape of a magnetoresistive element is a results effective variable.

143. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to control the dimensions of the spin valve (and thus of all of the layers making up the spin valve) in Saito so as to achieve a desired level of coupling between the free and pinned layers.

144. With respect to the limitations of claims 65-68, Saito as modified by Moon fails to teach a magnetoresistive element which utilizes a free magnetic layer in contact with a buffer layer which comprises 10-50 atomic % of a non-magnetic element added to the composition of the ferromagnetic layer in contact with the buffer layer, wherein the

saturation magnetization of the buffer is <0.2T and the buffer comprises at least one selected from Cr, Mo, and W.

145. However, Kamiguchi et al. (Kamiguchi) teaches utilizing a magnetic underlayer underneath and in contact with the free layer in a magnetoresistive element. This magnetic underlayer is a NiFe alloy which additionally contains an additive element se3lected from Ti, V, Cr, Mn, Zn, Nb, Mo, Tc, Hf, Ta, W, Re or the like. By placing the magnetic undercoat underneath the free magnetic layer, the magnetoresistance ratio is increased (column 7, lines 5-30 and figure 2).

146. Therefore it would have been obvious to one of ordinary skill in the art at the time the invention was made to utilize a NiFe alloy containing Cr, Mo, or W as taught by Kamiguchi beneath the free layer taught by Saito.

147. One would have been motivated to make this modification in lieu of the teaching in Kamiguchi that the magnetoresistance ratio of a magnetoresistive element is increased by utilizing a NiFe alloy that additionally contains Cr, Mo or W undernerath and in contact with the free layer. One would have specifically selected Cr, Mo, or W as the additive elements as Kamiguchi teaches their equivalence to the other elements listed as suitable for this purpose.

148. Regarding the amount of non-magnetic material and the saturation magnetization required by claims 65-68, although not expressly taught, it is well known in the art of magnetic materials that when non-magnetic elements such as Cr, Mo, and W are added to a magnetic alloys such as NiFe, the saturation magnetization of the NiFe alloy

decreases as the amount of non-magnetic element increases. Thus, the amount of non-magnetic elements added to the NiFe alloy is a results effective variable.

149. Therefore it would have been obvious to one of ordinary skill in the art at time the invention was made to control the amount of Cr, W, or Mo added to the NiFe alloy underlayer utilized by Saito as modified by Moon and Kamiguchi so as to achieve a underlayer that exhibits a desired level of saturation magnetization.

Allowable Subject Matter

150. Claims 23 and 72 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The following is a statement of reasons for the indication of allowable subject matter: There is no teaching or suggestion in the prior art to utilize a non-magnetic layer between adjacent magnetic layers in a free or pinned magnetic layer structure, wherein the non-magnetic layer is a multilayer film including at least one layer of non-magnetic metal and at least one layer of non-magnetic material selected from oxides, nitrides, carbides, and borides.

Examiner's Note

151. Without wishing to direct the applicant in any way, the examiner notes that many of the cited rejections can be overcome if the applicant more clearly defines the structure of the magnetoresistive element. In particular, if the applicant were to more clearly define exactly where the individual layers are located with respect to one another, many of the rejections would be untenable. Further, many of the claims contain parenthetical phrases that are not necessary and in the examiners opinion make the

claims more difficult to understand. The examiner respectfully requests the applicant consider claiming the information in these unnecessary parenthetic phrases in a manner that does not utilize parentheses.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nikolas J. Uhlir whose telephone number is 703-305-0179. The examiner can normally be reached on Mon-Fri 7:30 am - 5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul Thibodeau can be reached on 703-308-2367. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-305-0389.

NJU
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